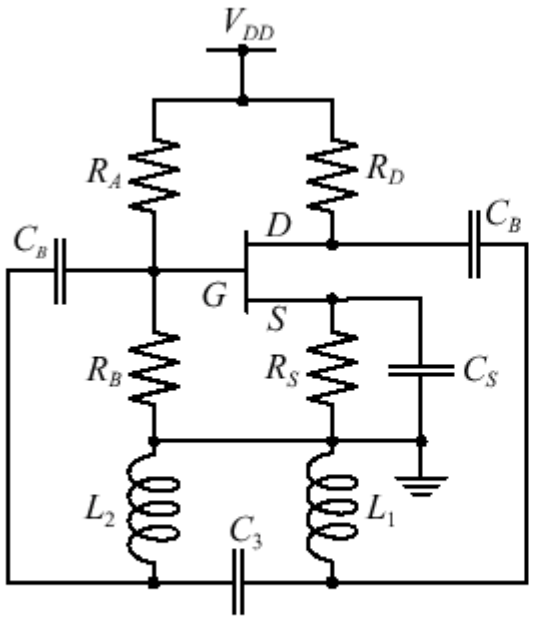
Basic Oscillator Model

- Oscillator has positive feedback loop at selected frequency
- Barkhausen criteria implies that the multiplication of the transfer functions of open loop amplifier and feedback stage is

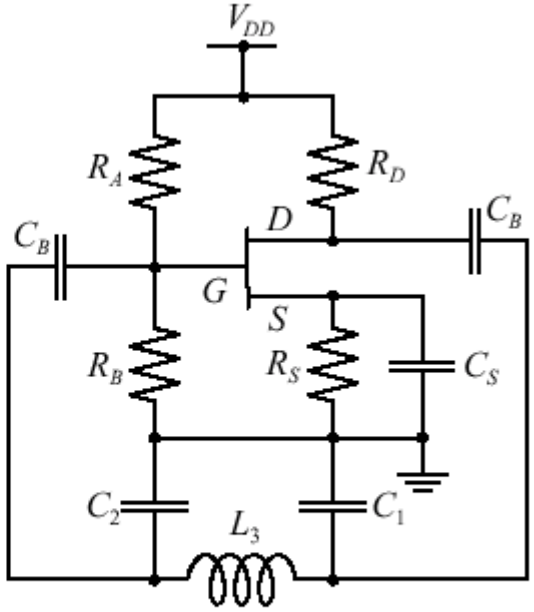
$$H_F(\omega)H_A(\omega) = 1$$

- Barkhausen criteria aka loop gain equation

LC Oscillators – Lower RF Frequencies

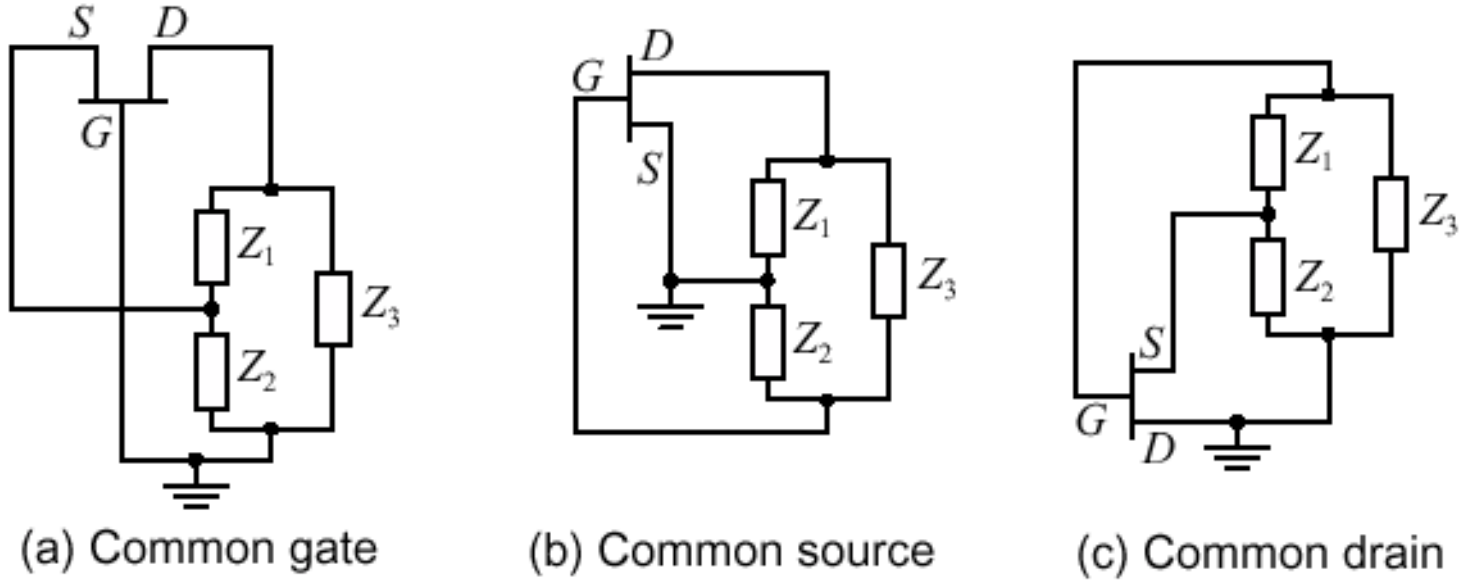


(a) Hartley oscillator



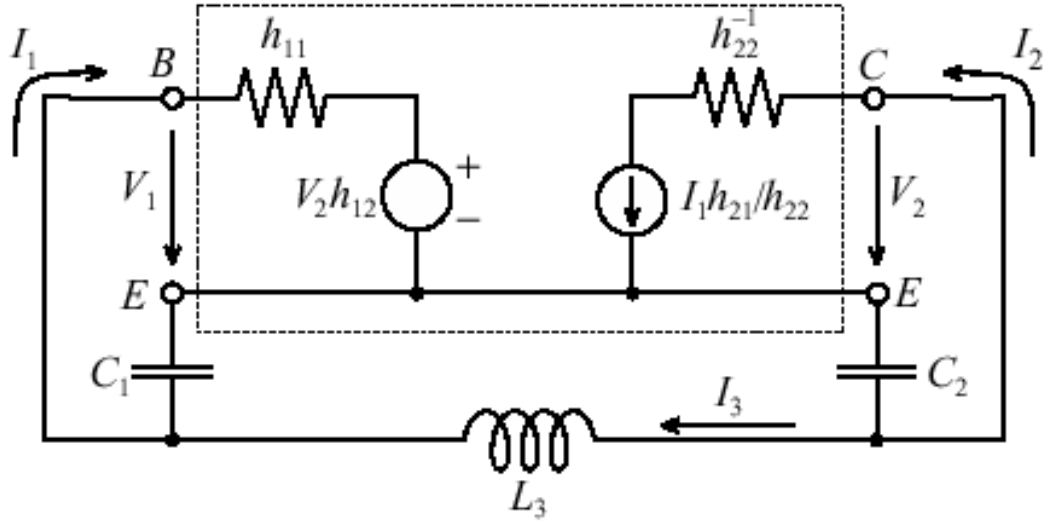
(b) Colpitts oscillator

LC Oscillators – Lower RF Frequencies



(a) Common gate (b) Common source (c) Common drain

LC Oscillators – Lower RF Frequencies

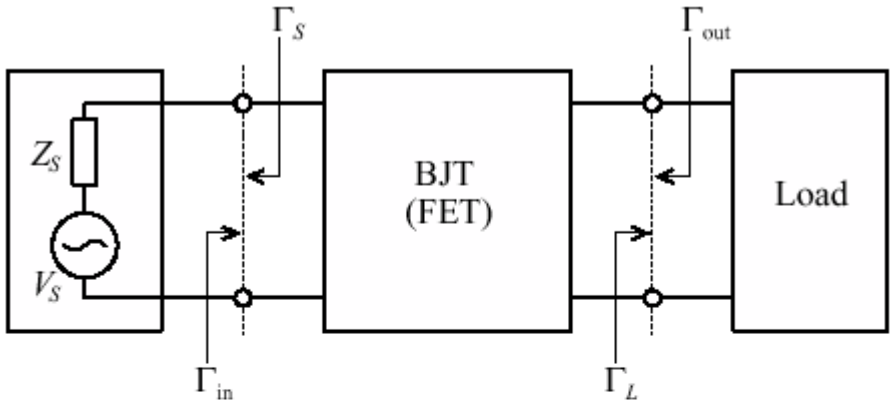


- Can also design with BJTs.

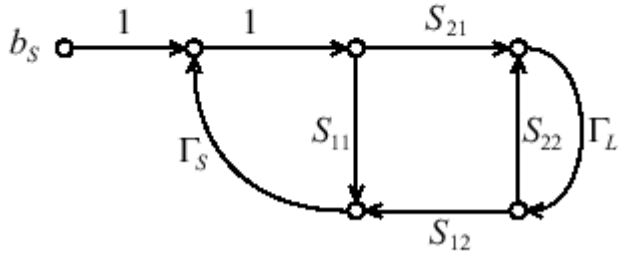
High RF & Microwave Oscillators

- Take advantage of our knowledge of stability
- Rollett Stability Factor $k < 1$

Microwave Oscillator Signal Flow



(a) Sourced and loaded transistor



(b) Equivalent signal flow graph

$b_1/b_s = \Gamma_{in} / (1- \Gamma_s\Gamma_{in})$

Conditions of oscillation –

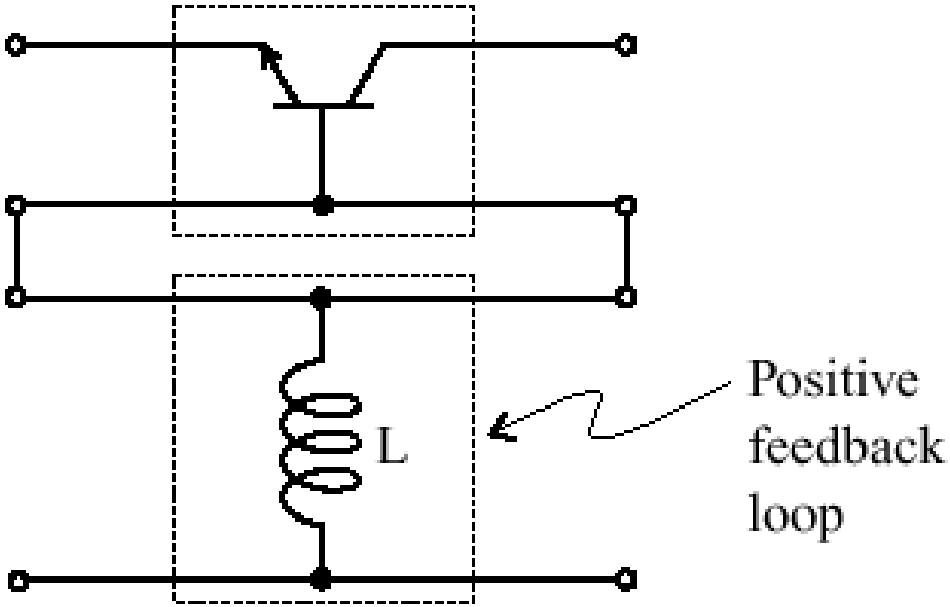
Unstable if:

$\Gamma_s\Gamma_{in} = 1$ or $\Gamma_s\Gamma_L = 1$

Creating Oscillator Condition

- Frequently begin with common-base or common-gate configuration
- Convert common-emitter s-parameters to common-base (similarly for FETs)
- Add inductor in series with base (or gate) as positive feedback loop network to attain unstable Rollett factor $k < 1$

Unstable Condition – Oscillation

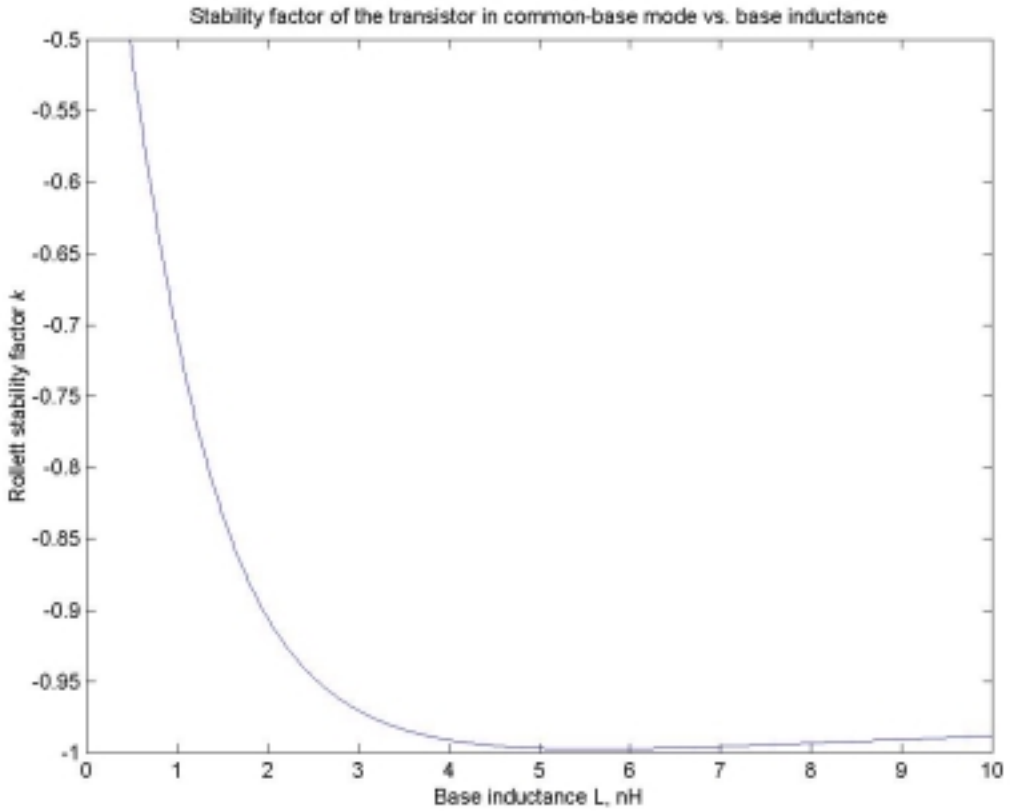


1. Convert transistor common-base [**s**] to $[\mathbf{Z}]_{tr}$
2. $[\mathbf{Z}]_L = j\omega L \begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix}$
3. $[\mathbf{Z}]_{Osc} = [\mathbf{Z}]_L + [\mathbf{Z}]_{tr}$
4. Convert $[\mathbf{Z}]_{Osc}$ to $[\mathbf{s}]_{Osc}$
5. Plot stability circles

Inductor Value for Oscillation

- Must repeat previous calculation of Rollet Factor for each value of L
- In this example

  L = 5 nH



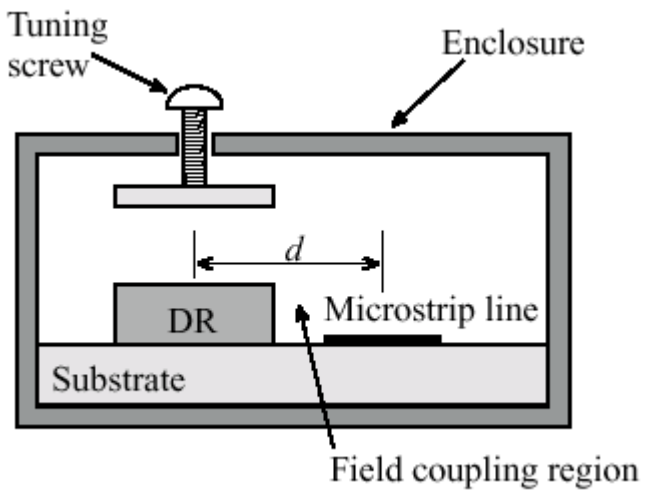
s_{11} = -0.935613, s_{12} = -0.002108,

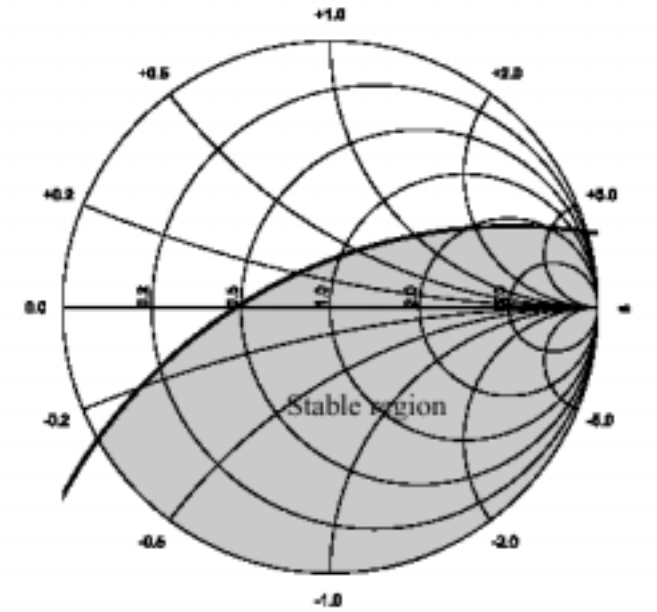
s_{21} = 1.678103 , s_{22} = 0.966101

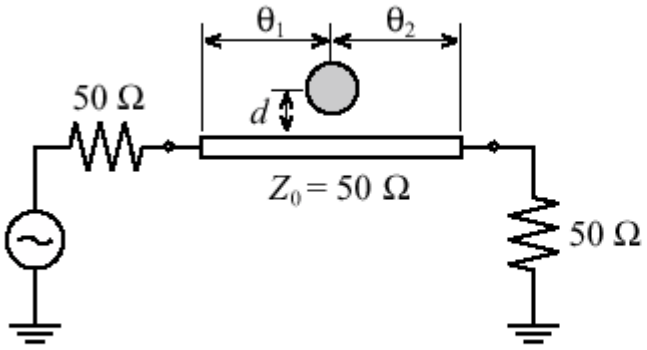
Unstable Transistor Oscillator Design

1. Select potentially unstable transistor at freq
2. Select appropriate transistor configuration
3. Draw output stability circle in Γ_L plane
4. Select appropriate value of Γ_L to produce largest possible negative resistance at input of transistor yielding $|\Gamma_L| > 1$ and $Z_{in} < 0$
5. Select source tuning impedance Zs as if the circuit was a one-port oscillator by $R_S + R_{IN} < 0$ typically $R_S = |R_{IN}|/3$, $R_{IN} < 0$ and $X_S = -X_{IN}$
6. Design source tuning and terminating networks with lumped or distributed elements

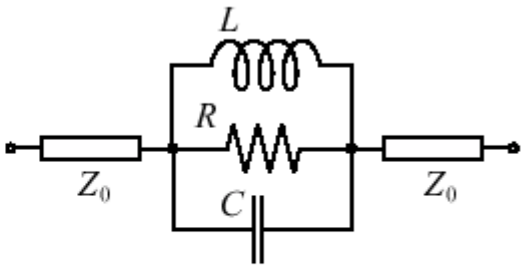
Dielectric Resonator Oscillator (DRO)





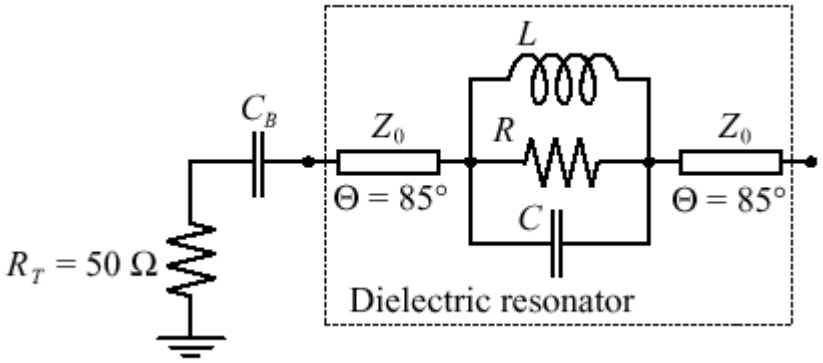


(a) Terminated microstrip line with DR

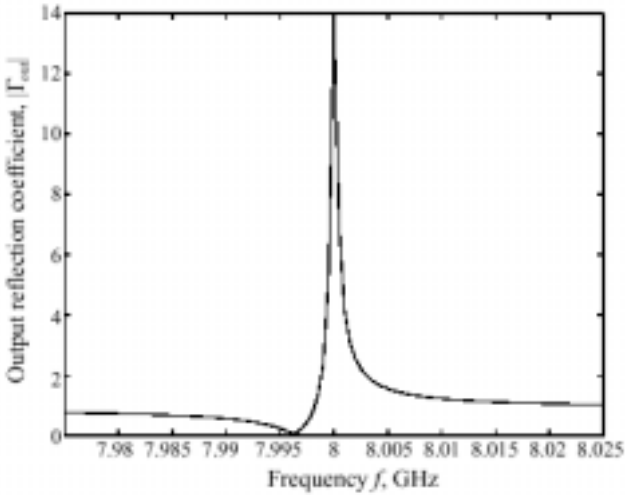


(b) Transmission line model

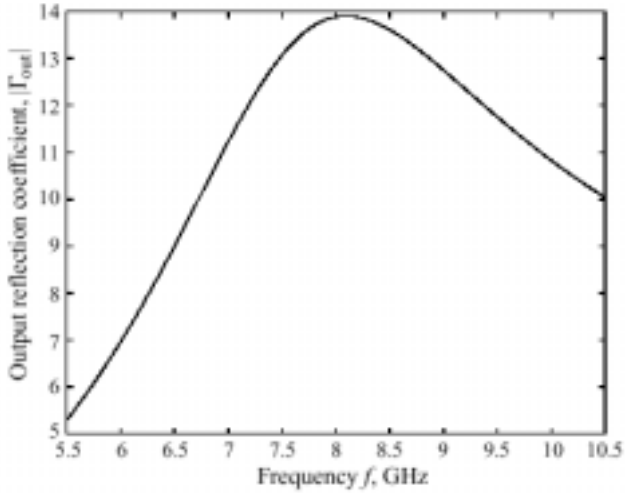
DRO Networks



DR-based input matching network of the FET oscillator

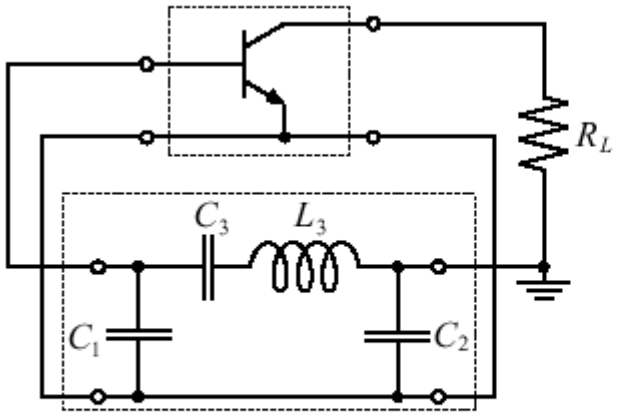


(a) Oscillator design with DR

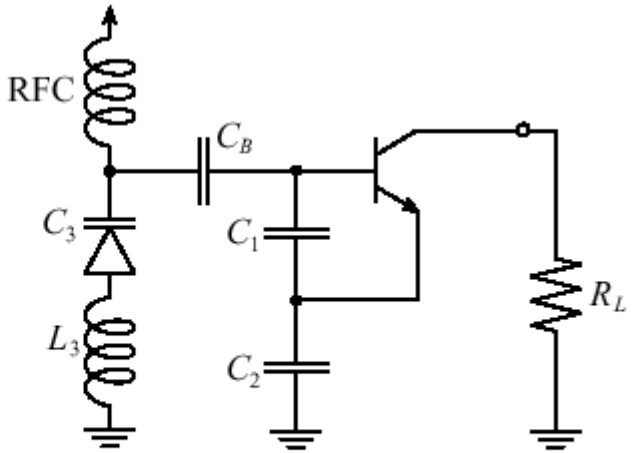


(b) Conventional oscillator without DR

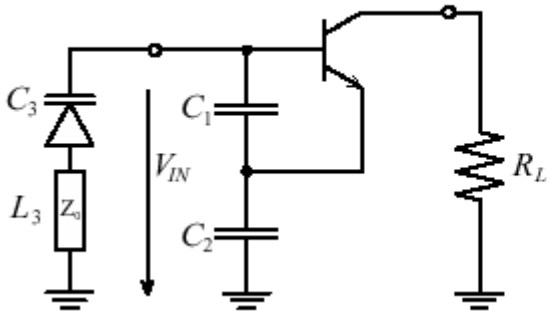
Varactor Diodes (Voltage Variable Caps)

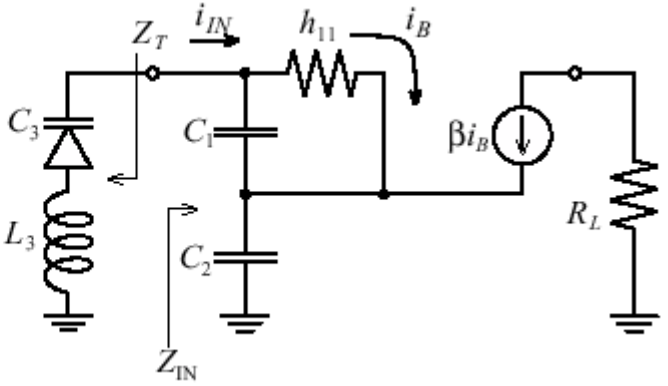


(a) Pi-type feedback loop

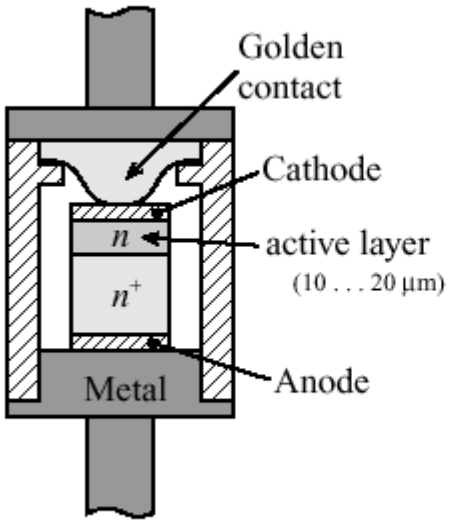


(b) Redrawn circuit with DC isolation

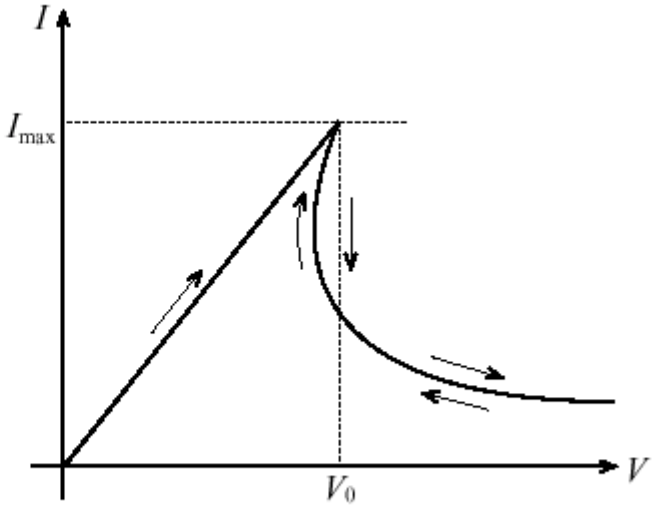




Gunn Elements For Oscillators

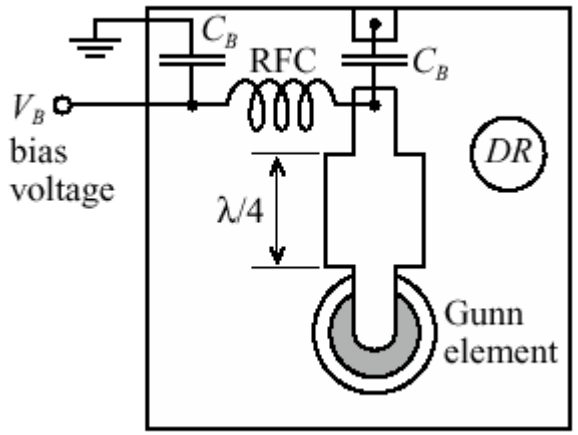


(a) Gunn element structure

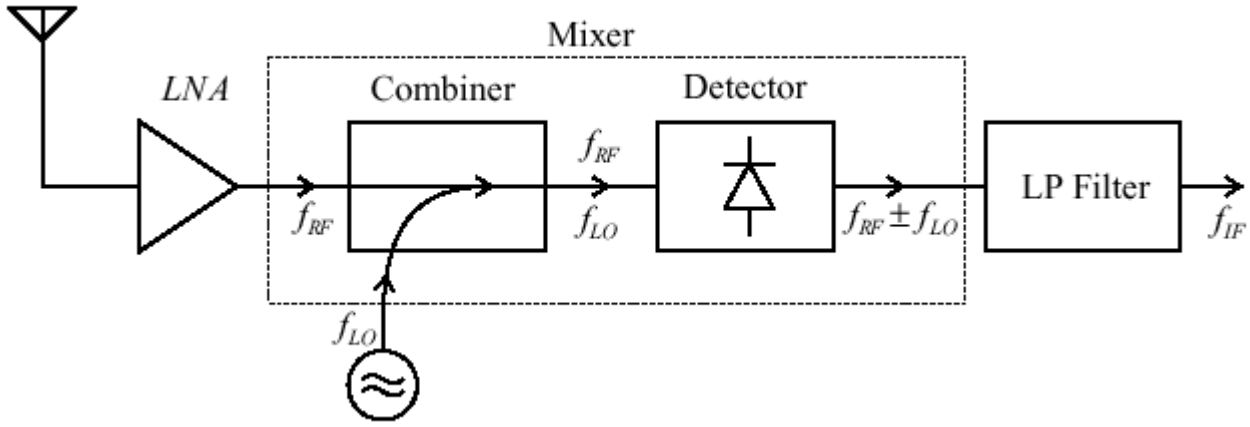


(b) Current vs. applied voltage response

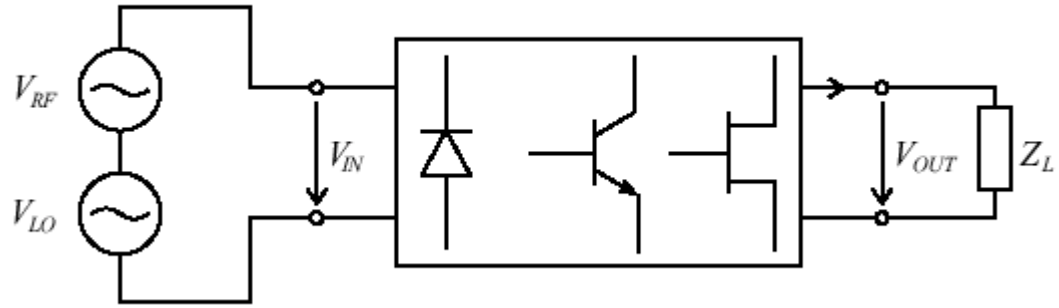
Gunn Oscillator with DRO



Mixer Basics

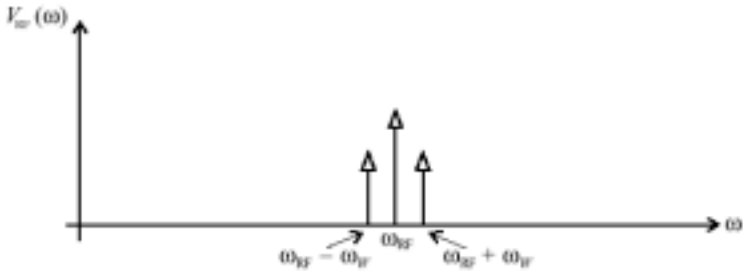


Heterodyne receiver system incorporating a mixer.

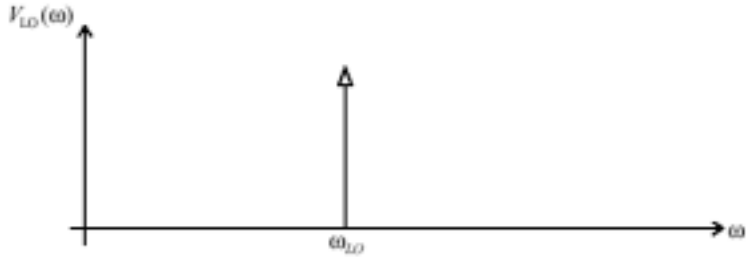


Basic mixer concept: two input frequencies are used to create new frequencies at the output of the system.

Mixing Process Spectrum



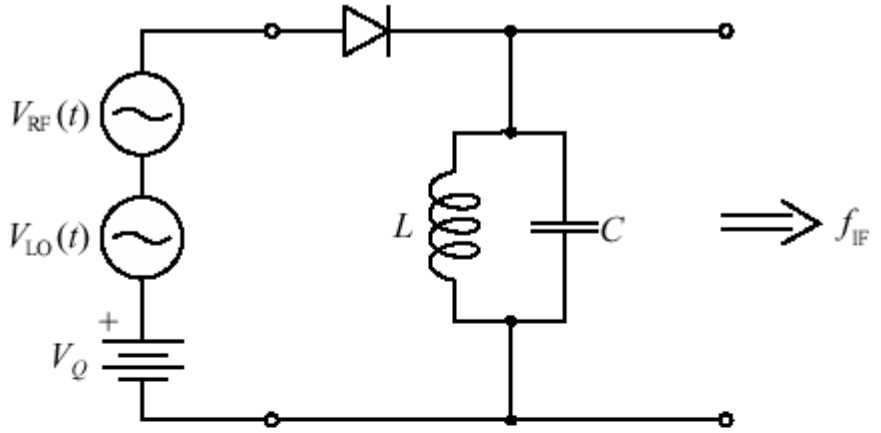
(a) RF signal



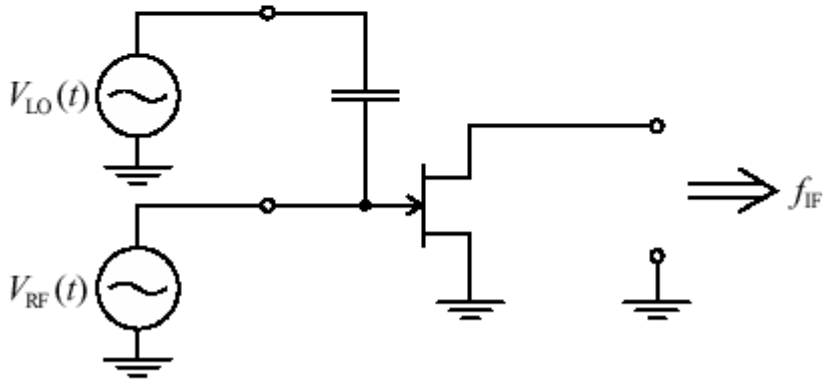
(b) LO signal

(c) Down- and upconverted spectral products

Simple Diode and FET Mixers

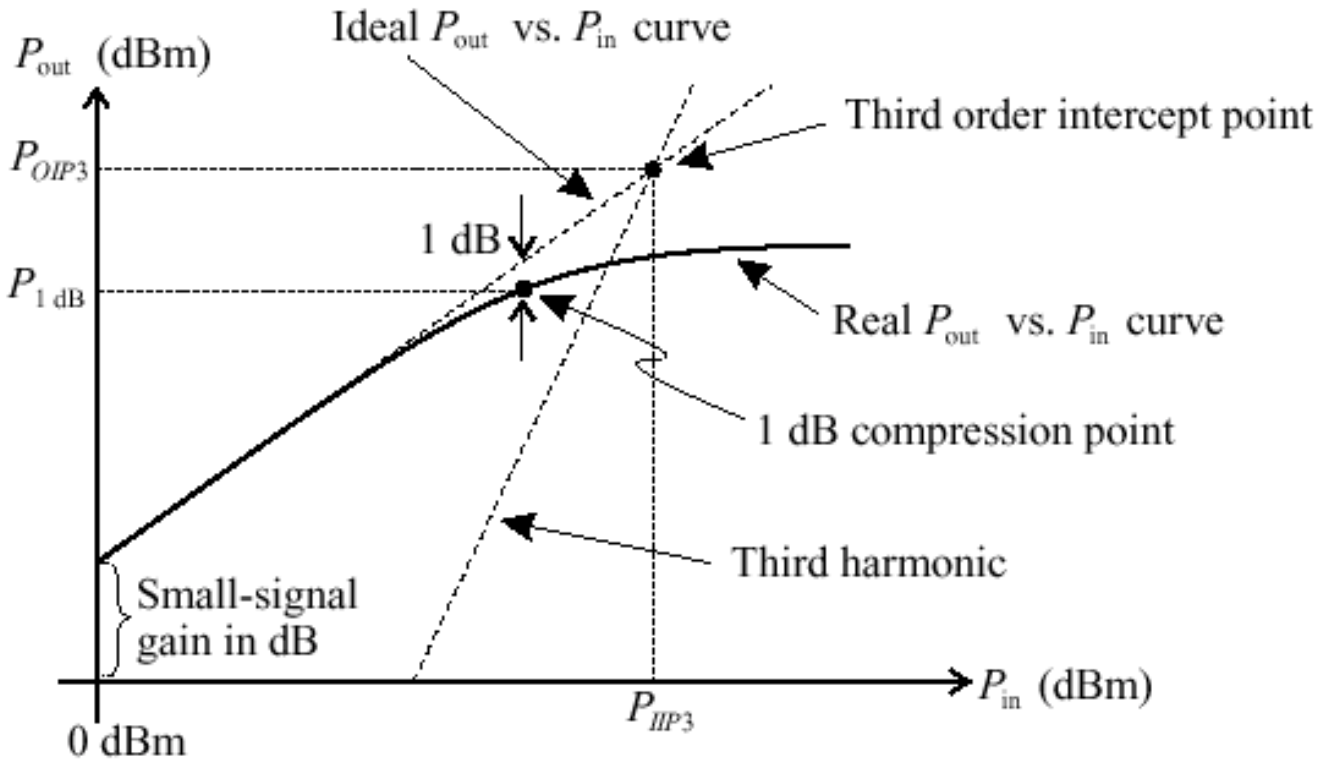


(a) Diode mixer

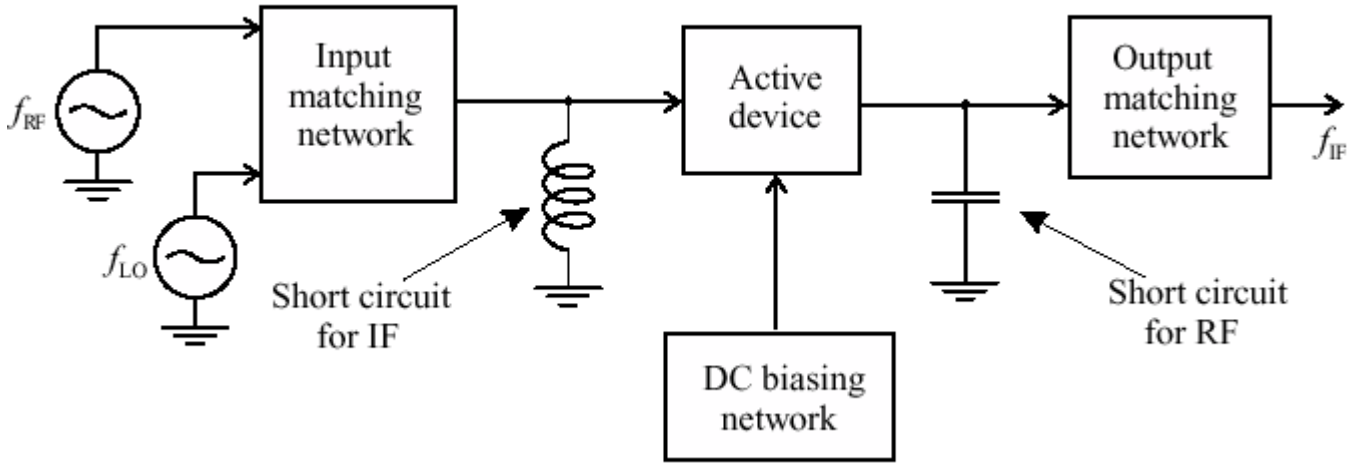


(b) FET mixer

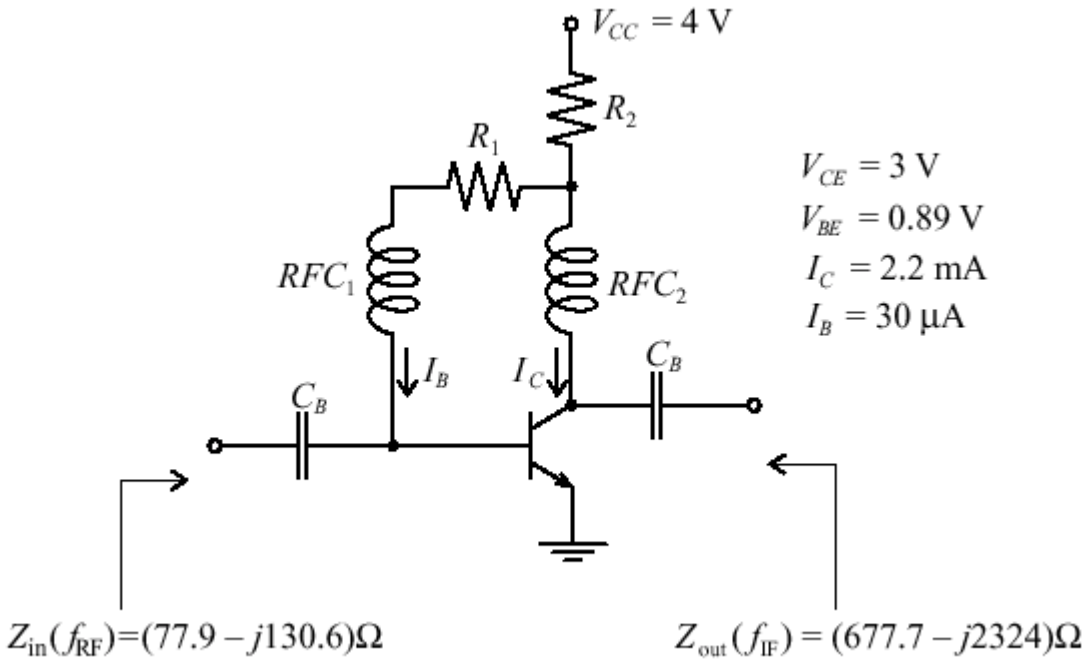
Compression Point and 3rd Order Intercept



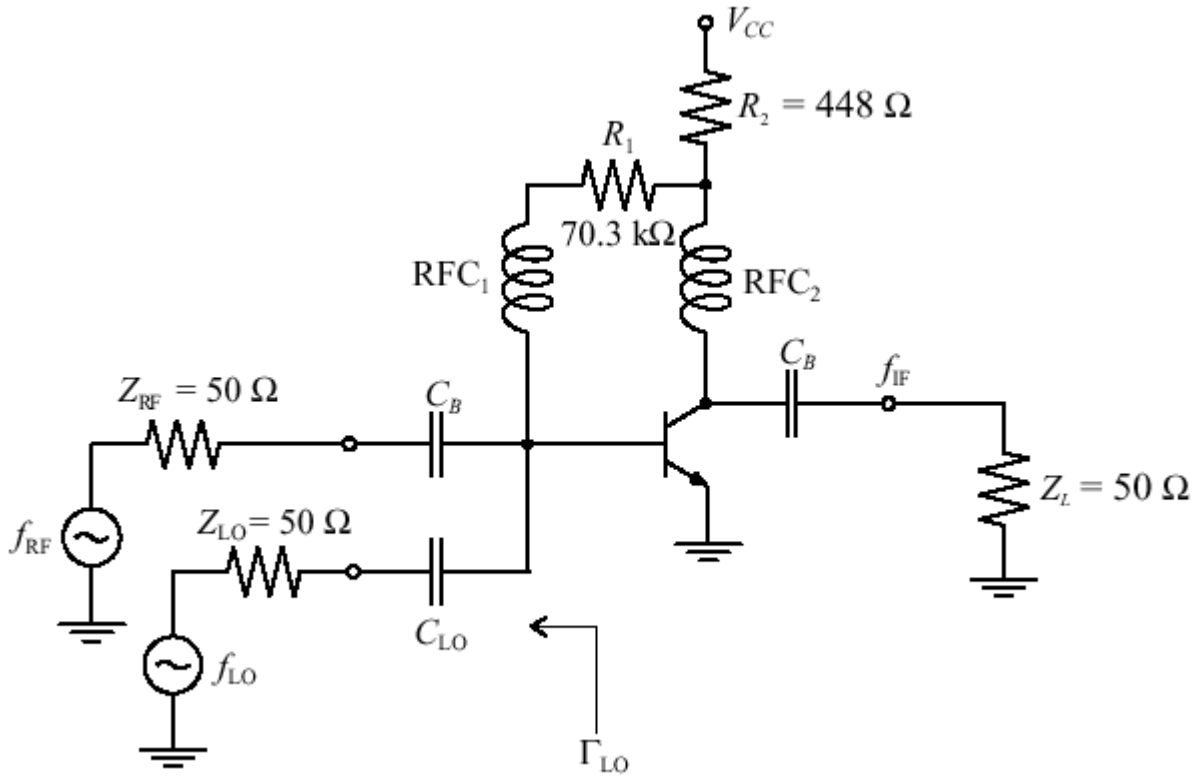
Single-Ended BJT Mixer



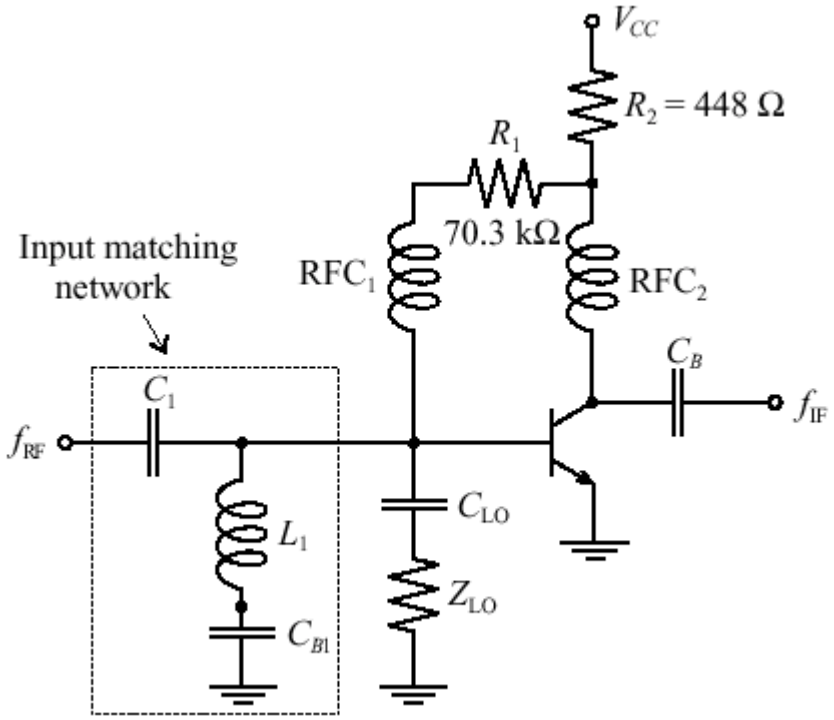
Single-Ended BJT Mixer Design
Biasing Network



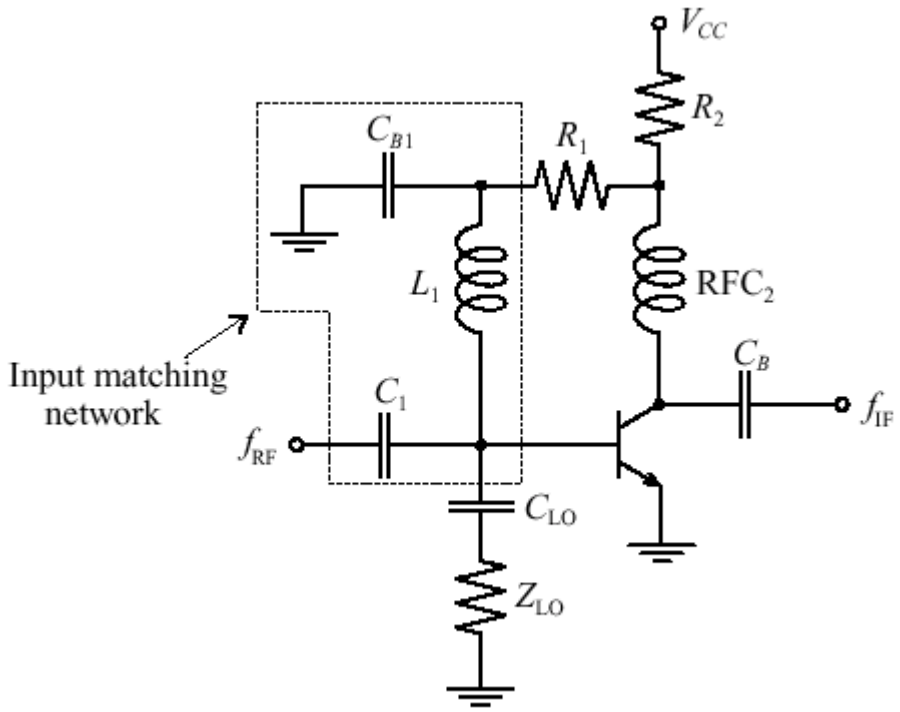
Single-Ended BJT Mixer Design
LO and RF Connection



Single-Ended BJT Mixer Design
RF Input Matching Network



Single-Ended BJT Mixer Design
Modified Input Matching for RF



Single-Ended BJT Mixer Design
Completed Design